College and Career Readiness Skills – Comparability Study

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PLTW

Project Lead The Way

EdImagine

PLTW Executive Summary

This executive summary has been compiled by PLTW utilizing the data and information from the comparability study conducted by Drs. Conley and Seburn. Some content within this summary is taken directly from the study verbatim, but other parts have been redacted for length, or the wording has changed with the reader in mind. The full study can be shared upon request.

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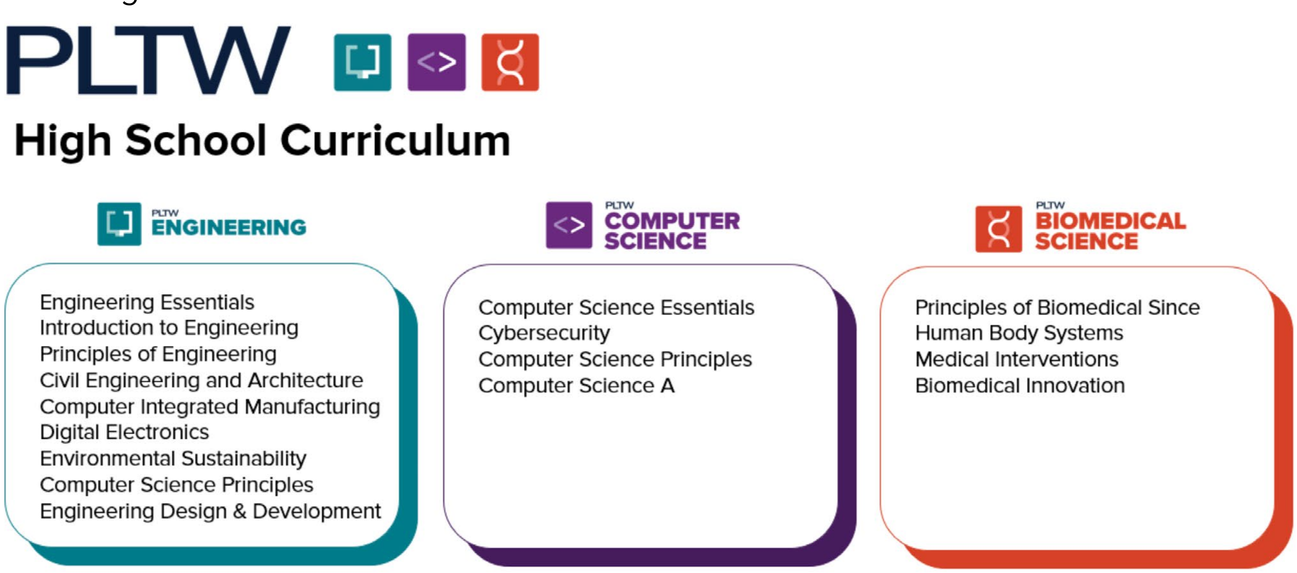
Background

This report provides results from a comparison study of Project Lead The Way's (PLTW) high school courses and End-of-Course Assessments (EoCs) completed by Dr. David Conley and Dr. Mary Seburn in December 2022. PLTW engaged Dr. Conley and the EdImagine team to conduct a comparability study of all PLTW high school courses and the associated End-of-Course Assessments. Dr. Conley is the founder and president of EdImagine, a consultancy helping educational organizations improve effectiveness and strategic direction. He also serves as Professor Emeritus of Educational Policy and Leadership in the Department of Educational Methodology, Policy, and Leadership, College of Education, University of Oregon; and was founder of the Educational Policy Improvement Center (EPIC, now Inflexion). In addition, Dr. Conley has contributed to college and career readiness research, including conducting and publishing many foundational research studies and books.

Dr. Mary Seburn, Senior Director of Research Design and Advanced Analytics at EdImagine, has more than 20 years of experience in measurement, assessment, evaluation, and data analysis. She designs and applies research to solve practical problems, often focusing on challenges faced by first-generation college students. A social and personality psychologist, her specialties include creatively combining qualitative and quantitative approaches in research design, applying professional validity standards to complex programs to build a foundation for technical documentation and actionable reports to stakeholders, and using program evaluation to answer questions that leaders do not yet know they have.

Founded in 1997, PLTW provides access to PreK-12 STEM curricula to more than 12,400 U.S. schools and millions of students nationwide, ensuring a transformative learning experience for both teachers and students. PLTW's innovative hands-on Activity, Project, and Problem-Based (APB) approach is woven throughout three pathways: computer science, engineering, and biomedical sciences (Figure 1). These pathways provide teachers and students classroom experiences that develop the industry-in-demand knowledge and skills necessary to thrive in 21st century STEM careers. Each course is embedded in foundational content knowledge and transportable skills, such as problem-solving, creative and critical thinking, communication, and logical reasoning. These skills and experiences help prepare students to thrive in post-secondary education and the workplace.

Figure 1.
PLTW's High School Courses



This comparability study analyzed the content knowledge and transportable skills of PLTW's high school courses and the associated EoC Assessments using the Four Keys to College and Career Readiness, a comprehensive set of college and career readiness elements developed by Dr. Conley (Conley, D.T., 2007). The EoC Assessments are uniquely designed to assess students' content knowledge and transportable skills through applied scenarios and complex item types. Post-secondary institutions can utilize scores from the EoC Assessments to award a variety of student opportunities, such as college credit, scholarships, preferred admissions, etc.

Purpose of Study

The overarching goal of this study is to compare the content of PLTW's high school courses and the associated EoC Assessments to the skills that industry and colleges have deemed important for success. The four key objectives of the study are:

1. To help inform program improvement
2. To inform ongoing revisions of curriculum and assessments
3. To create confidence that HS pathways and EoC Assessments align or compare well with standards for college and career readiness
4. Provide additional validity evidence that supports the use of course participation, grades, and EoC scores as an indicator of student college and career readiness.

Project Lead The Way posits that their courses prepare students for college and careers, ensuring success in both post-secondary and career tracks post high school graduation. It is important to note that the PLTW courses and EoC Assessments were not explicitly designed to align with this comprehensive set of empirically derived college and career readiness elements. However, comparing PLTW offerings with these college and career readiness elements highlights inherent characteristics in PLTW coursework that prepare students for post-secondary endeavors, and the EoC Assessment as an indicator of this preparation. This distinction differentiates this as a comparability study rather than an alignment study. It should not be expected that the courses or exams will necessarily contain all or most of the criteria to which they are being compared. Understanding the college and career knowledge and skills PLTW courses develop in students and how EoC Assessments measure those skills enables PLTW to explicitly share with current and future implementers what their courses provide regarding career and college preparation. This understanding also allows PLTW to evolve courses and exams that enhance the degree to which the courses develop and measure college and career learning skills.

Methods

The review of courses was completed using a modified model (Figure 2) based off of the Four Keys to College and Career Readiness Model (Conley, D.T. 2007). The modifications to the model for this analysis include combining similar constructs (evaluation and analysis, for example), and emphasizing higher-order skills and strategies (e.g., linking ideas instead of facts or terms) to be more sensitive to the content of PLTW courses. In addition, problem formulation was relabeled as problem definition, a key component of problem formulation that can be more readily recognized in courses. This model contains most of the commonly identified 21st Century Skills. However, it does not include some less-frequently mentioned 21st Century Skills such as media literacy, social responsibility, financial literacy, health and wellness literacy, humanitarianism, or environmental or ecological literacy.

This consolidation resulted in the 25 elements listed in Figure 2 against which the PLTW courses and exams were compared.

Figure 2.

Four Keys to College and Career Success - Modified

Key Cognitive Strategies

- Problem Definition*
- Strategic Thinking*
- Information Literacy*
- Scientific Method
- Critical Thinking*
- Creativity*
- Precision/Accuracy
- Academic Communication*
- Interpersonal Communication*
- Professional Communication

Key Content Knowledge

- Foundational Knowledge
- Linking Ideas
- Technological Literacy*
- Right Attitude: Curiosity
- Right Attitude: Growth Mindset

Key Learning Skills & Techniques

- Motivation
- Progress Monitoring
- Persistence*
- Self-awareness*
- Learning Skills
- Self-Management Skills

Key Transition Knowledge & Skills

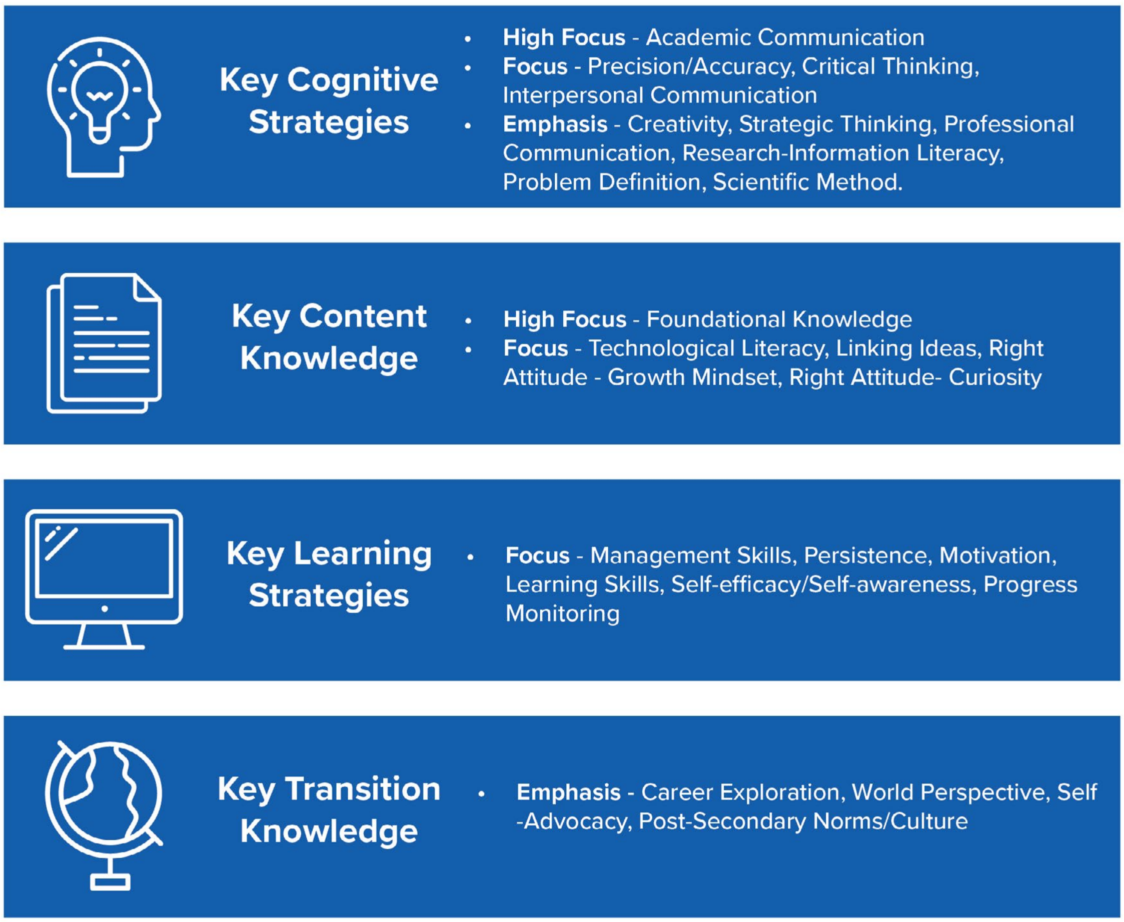
- Career Exploration
- World Perspective*
- Post-secondary Norms/Culture
- Self-advocacy

Note. Asterisk (*) indicates elements that correspond to what have been referred to commonly as "21st Century Skills."

As a result of the document and item analysis methods used by the researchers, it was determined that overall, each of the 25 elements were covered with variable levels of emphasis as captured in Figure 3. Areas with High Focus were consistently seen in more than 75% of the lessons, Focus elements were seen in 50-75% of the lessons and Emphasis elements were seen in 50% or less of the lessons.

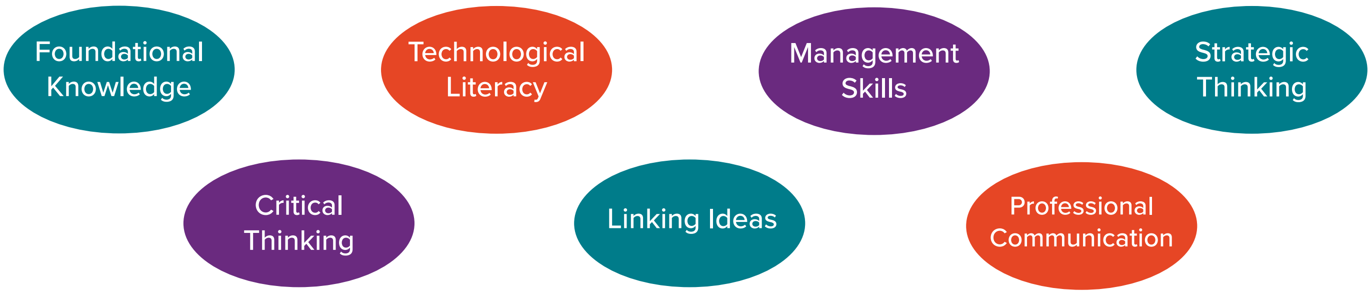
Figure 3

Overall Emphasis in Course Lessons

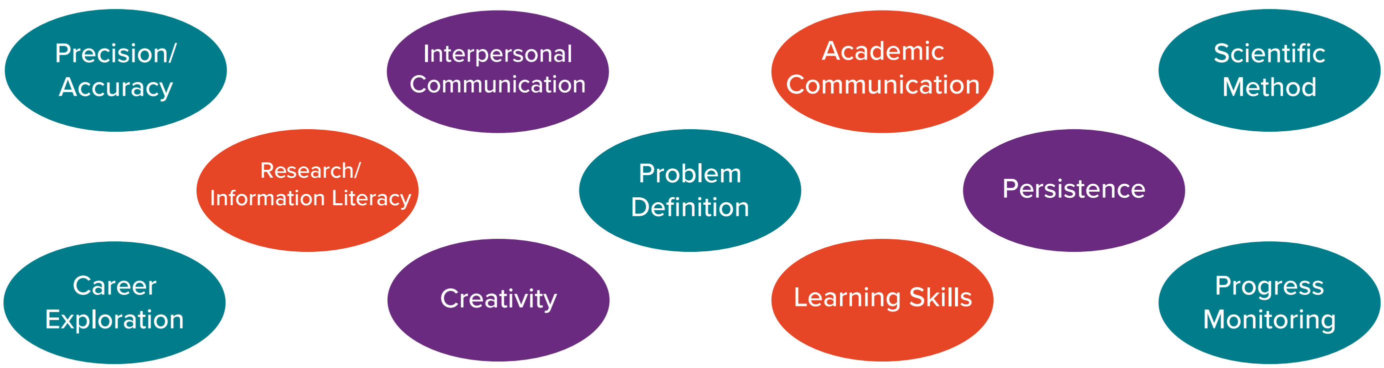


Additionally, within each course, researchers reviewed the EoC Assessment items. Each course assessed between 4 and 18 elements. A standardized assessment cannot assess all of the 25 elements due to the nature of the skill. Items like motivation, self-advocacy, and citizenship are more appropriately assessed within the course using other course methods like rubrics, scoring guides, peer evaluation, portfolios, quizzes, and classroom tests.

The most prevalent elements assessed are:



Skills that are found to be in multiple EoCs are:



Conclusion

This comparison study of PLTW's high school courses and their associated EoC Assessments validates PLTW's assertion that students who participate in PLTW courses are well-prepared and well-equipped for college and careers after high school. Courses consistently and strongly address all of the elements researchers have shown are essential to post-secondary success. Every PLTW high school course studied addressed all or the majority of the Four Keys college and career readiness elements, a unique and remarkable find that reaffirms the PLTW mission as realized in the curriculum. Moreover, the EoC Assessments address numerous elements--more than other similar on-demand, standardized assessmentswhich tend to focus primarily on content knowledge. These findings definitely demonstrate the incorporation of key college and career readiness skills in all courses and EoCAssessments.

In a time where colleges are transitioning to "test-optional" for admissions requirements, PLTW's college and university partners are increasingly utilizing the students' performance in their courses and on the EoC Assessments to recruit students and provide opportunities like college credit and scholarships. Additionally, PLTW teachers will be able to identify and foster the elements of college and career preparation to help students focus on these important areas. PLTW students are positioned to showcase their foundational knowledge and transportable skills in various ways to assist in achieving post-secondary and career success.

Appendix A: Glossary of Terms

This Appendix provides coding definitions and examples of how some elements appeared in the course lessons and activities. Examples are from the Engineering Pathways Introduction to Engineering Design (IED) course; no examples of the EoC Assessments are provided due to test security.

KEY COGNITIVE STRATEGIES

Problem Definition

Student engagement to identify, define and understand a problem. Does not occur when pre-defined problems are provided; increases ownership of learning. An example of Problem Definition is below.

> Review the partially completed Project 1.3.7 Design a Protective Case Design Brief to become familiar with the design problem. With your partner, complete the design brief by addressing each of the following:
> - Develop a design statement that describes exactly what you will do in Phase 1 of the project. Remember you are only providing proof of concept and need only deliver the items listed in the Deliverables section of the design brief.
> - Add one or more **measureable** criteria to specify the size of the protective case solution.
> - Add measureable criteria that will help define a successful solution based on the purpose of your prototype.

Strategic Thinking

Creating and applying a strategy to solve a problem; includes monitoring the effectiveness of a strategy selected to solve a problem; monitoring the completeness of a solution obtained by the selected strategy. It should be iterative in response to feedback or progress monitoring, which develops cognitive flexibility. Resourcefulness.

> Plan your learning. Make a list of your goals for this project. What will you try to learn or achieve while competing this project?
>
> *Introduction to Engineering Design, 1.2.5; 1.3.7.*

Research

Strategies include information literacy and the scientific method.

Information Literacy

is necessary to identify and evaluate potential sources of data or information, to factually record events, data, or observations; and to gather necessary and sufficient information from a variety of appropriate sources.

Scientific Method

Understanding of and ability to plan, carry out, analyze, and report conclusions based on the scientific method.

Critical Thinking

Analysis, evaluation, inference, reasoning, synthesis, interpretation or any other rational, logical, and academically disciplined processing of information or data.

> Predict the behavior of your sketch if you were to change the base dimension from 100mm to 125mm.
>
> *Introduction to Engineering Design, 1.2.5.*

Creativity

Thinking with fluency, flexibility, and with an element of the unusual in response to a problem or question. Innovation, design thinking, artistry. The ability to discover new and original ideas, connections, and solutions to problems. Requires tasks or problems with multiple solutions.

> Brainstorm and quickly develop three conceptual charm design ideas to represent your partner. Keep in mind that time is money - the time you spend on design of the charm costs the company money (in your salary and in opportunity for you to work on something else).
>
> *Introduction to Engineering Design, 1.2.5.*

Communication

Intertwined skills necessary to organize information to meet task needs and audience; and to use that data or information to construct an appropriate form of communication (paper, tweet, portfolio, memo). Includes Academic, Interpersonal and Professional Communication Skills.

Academic

Mostly oral and written communication in the form of traditional papers and class discussions, assignments, and presentations.

> **Discussion Prompt:** Models can be created using different tools and techniques. For example, a cylinder can be modeled using Extrude or Revolve. As a class, discuss if one method is better than the other.

Interpersonal

Formal and informal goal-directed interaction with peers or teachers, includes listening skills, respect, and practice in multiple roles (leader, contributor, tutor). Collaboration, teamwork.

Professional

Subject-specific or professional communications, such as proofs or memos or interactions, simulated or actual, with the professional community associated with the subject.

> Engineers and architects often have a need to communicate the complex details of internal features of their designs. They use sectional views on technical drawings to represent a view of the design as if it were sliced by an imaginary plane and part of the sliced object removed to display the inside of the design. Professionals in other fields also use sectional views to communicate important information.
>
> *Introduction to Engineering Design, 1.3.6.*

Precision/Accuracy

Reflective thinking about the nature and quality of one's work and on one's own learning; includes comparing work products to a set of standards (internal or external) or criteria for success and revising as needed. Integrity. Conscientiousness. Attention to detail.

> Individually, develop a CAD model and multi view drawing of your assigned component based on the new dimensions you have selected for the box. Use the same hinge design and snap-fit clasp design used in the competitor's protective container. Work with your partner to ensure that:
>
> - The cylindrical hinge forms on each part align with each other.
> - You have a 0.5mm gap between the parts at each hinge interface.
> - The snap-fit clasp on the top aligns with the rectangular receiving hole on the bottom.
>
> *Introduction to Engineering Design, 1.3.7.*

KEY CONTENT KNOWLEDGE

Foundational Knowledge

Linking Ideas

Connections built upon more basic knowledge such as facts, terms, and organizing concepts by linking them into new constructs and understandings. Higher order thinking about knowledge, its structure and evolution.

> Two types of constraints can be applied when building the geometry of a 3D solid CAD model: dimensional constraints and geometric constraints. You used dimensional constraints in CAD when you applied dimensions to geometric primitives, when you dimensioned sketches, and when you defined dimensions of features. In this activity you'll learn about geometric constraints, and how a combination of geometric constraints and dimensional constraints can fully constrain model geometry.
>
> *Introduction to Engineering Design, 1.3.3.*

Technological Literacy

Familiarity and facility with online collaboration workspaces and technology tools, internet literacy, programming, task-specific technical tools/tools of the trade.

> Investigate the tools available in your CAD program that allow you to slice and view the inside of a model.
>
> *Introduction to Engineering Design, 1.3.6.*

Right Attitude

Being receptive to learning.

Curiosity

Recognizing the value of what is learned and seeing relevance in learned topics, being interested and curious. Facilitated by student-led work, focusing on questions instead of answers, making connections and having a growth mindset.

1. Why can we never know the exact measurement of anything? What factors might contribute to the uncertainty of a measurement?
2. Compare the precision of the measuring tools you used in this activity - the ruler and the dial caliper. Give an example of when you might use each tool.
3. Compare the precision of the dial caliper and the precision of the hole diameter measurements your team measured (step 11) using the data you collected. How would you explain the difference between the precision of the tool and the precision of the measurement values to a student not in the class?
4. Choose an industry and research precision measurement applications in that industry. Identify at least one example of precision measurement technique or device and answer the following questions:

- How is the precision measurement technique or device used?
- What is the precision of the technique or device?
- Why is this precision necessary to accomplish the purpose of the measurement?
- What is the risk of inaccurate or imprecise measurement?

Introduction to Engineering Design, 1.3.1.

Growth Mindset

The belief that talents can be developed through hard work, good strategies, and input from others; seeking appropriately and increasingly challenging tasks.

KEY LEARNING STRATEGIES

Motivation

Self-directed and active engagement in learning. Motivation is highest when students are competent, sufficiently autonomous, set worthwhile goals, have transparent success criteria, receive feedback and are affirmed. Multi-step activities, with supports, model this. Student activities present goals for each lesson and include rubrics or resources establishing success criteria.

With a partner, perform additional research, as necessary, to respond to the following:
a. Explain the difference between parallel and collinear.
b. Explain the difference between two circles that are tangent and two circles that are concentric.
c. Can the tangent constraint be applied between a line and an arc?

Introduction to Engineering Design, 1.3.6.

Progress Monitoring

Identify goals and seek out and incorporate feedback over time to independently monitor progress towards meeting goals; make strategic adjustments as needed and seek help when appropriate and available.

Discussion Prompt: Revisit the list of learning goals you created at the beginning of the project. How are you doing? What questions do you have related to what you hope to learn?

Introduction to Engineering Design, 1.3.7.

Persistence

Able to put forth sustained task-oriented attention and effort over time, even when challenged. Persistence, perseverance, determination, resilience, discipline. A voluntary continuation of goal-directed action in spite of obstacles, difficulties, or discouragement.

Self-efficacy

Having a sense of personal control over one's learning (internal attribution). Effective self-control requires self-awareness, a sense of autonomy, and self-helping as a result of progress monitoring. Developed through opportunities to reflect on learning, understanding and strategy effectiveness.

> **Project Reflection.**
> According to your teacher's instructions, reflect on the following prompts:
> 1. Reflect on your work and consider ways that the final product or process could be improved.
> - Does the final product align with your design statement?
> - Did you meet all of the criteria and constraints?
> - Was the customer satisfied with the final product?
> - Could resources (time or material) be used more efficiently at any step of the process?

Learning Skills

Foundational skills that facilitate learning. Include note-taking systems, memorization schemes, instruction given or practice undertaken in preparation for taking a test.

> **How do you apply it?**
> Apply Occam's Razor when comparing competing solutions. If two solutions meet the design requirements and perform the desired function in similar ways, choose the simplest design. Then evaluate each element of the chosen design and remove design elements that do not contribute to the performance of the function.
>
> *Introduction to Engineering Design, 1.3.7.*

Management Skills

Time-management skills are the tools used to enable and support the closely related but more sophisticated Strategic Thinking and Progress Monitoring skills, such as using timelines, lists, calendars, prioritization or other task, project, or time planning and organization tools.

Sample Software Project Schedule

			WEEKS										
TASK/MILESTONE	ASSIGNED TO	TIME REQUIRED (WEEKS)	1	2	3	4	5	6	7	8	9	10	11
Schedule/hold on-site meetings	PM- Skylar Jones	1											
Discuss needs with stakeholders	Linda Ortiz	2											
Observe on-site process	Linda Ortiz	1											
Analysis report	Linda Ortiz												
Design database	Chris Smith	2											
Design software	Chris Smith	2											
Design interface	Chris Smith	2											
Create design specifications	Nick Candor	2											
Specification template design	Alex James	2											
Design specification document	Skylar Jones												

Introduction to Engineering Design, 3.3.2.

KEY TRANSITION SKILLS

Career Exploration

Exposure to different careers, training paths and levels, job-specific skills, as well as community, home and work roles.

CAREER CONNECTIONS

Medical Imaging with Computed Tomography (CT)

Computed tomography (CT) is a type of medical imaging procedure that creates detailed images of areas inside the body. A CT scanner spins a circular frame that supports an X-ray tube and detector around a patient to generate sectional views of the patient. The images created allow medical professionals to see inside the human body to diagnose, monitor, or treat medical conditions.

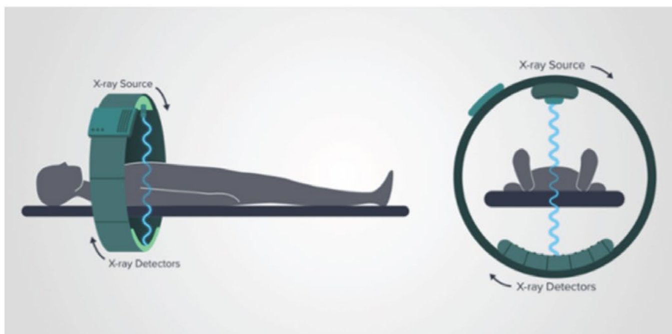


Figure 3. Computer Tomography (CT) Scan

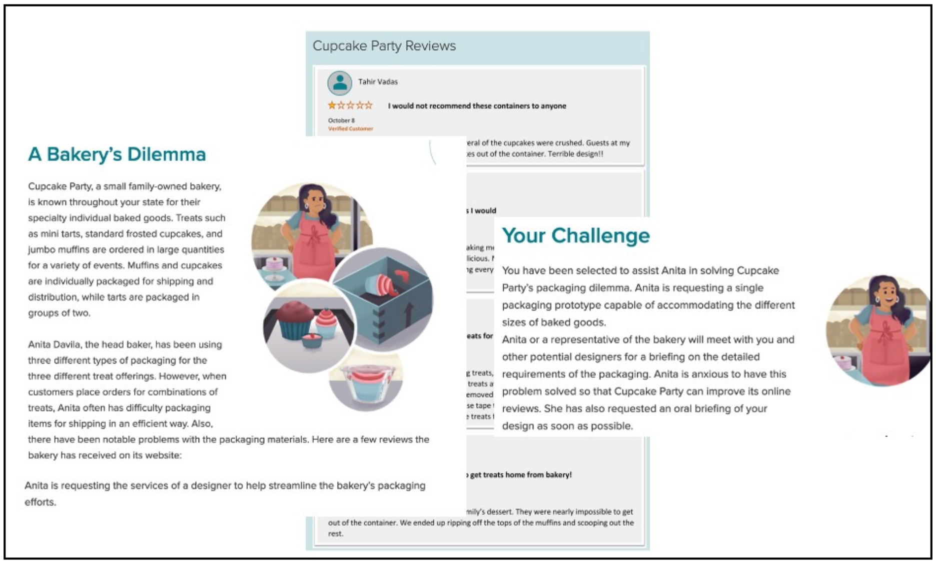
During a CT procedure, the patient lies on a horizontal table surface and is moved through the scanner as the scanner rotates. An x-ray beam is projected, and as the beam passes through the body some of the energy is absorbed or scattered, reducing the intensity of the beam before it is detected. The reduction of x-ray intensity is called attenuation. Different types of materials (water, fat, bone, air, and so on) attenuate the x-ray beam at different rates. Data related to the x-ray intensity received by the detector is collected and converted to an image. In older CT scan images, bone appears white and air appears black. In modern CT scan images, color-coding can be applied to the data set and different materials are differentiated by color.

Introduction to Engineering Design, 1.3.1.

Post-secondary Norms

Exposure to postsecondary – college or career - environments, situations, or cultures.

World Perspectives
Exposure to the world, including different environments, situations, traditions or cultures.



Self-advocacy
Speaking up for oneself, staying informed, finding support, and navigating institutional environments and systems.

> **Important:** Ask your teacher questions if you are unclear about the project expectations, especially the project deliverables, associated with the problem.
>
> *Introduction to Engineering Design, 2.4.1.*

References

Conley, D. T. (2007). Redefining College Readiness. Eugene, OR: Educational Policy Improvement Center; Conley, D. T. (2014). Getting ready for college, careers, and the Common Core: What every educator needs to know. San Francisco, CA: Jossey-Bass.

http://edimagine.com/

For access to the complete 2022 Conley Study, please reach out to the PLTW Assessment team.